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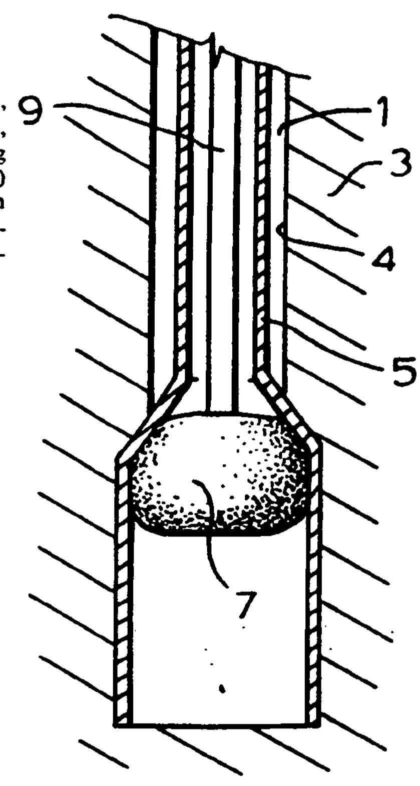
(54) Title: METHOD OF CREATING A WELLBORE IN AN UNDERGROUND FORMATION

(57) Abstract

A method of creating a wellbore in an underground formation is provided, the method comprising drilling a borehole (1) in the underground formation (3), lowering a casing (5) of a malleable material into the borehole, said casing being radially expansible against the borehole wall upon application of a radial load (7) and having a smaller elastic radial deformation than the surrounding formation upon application of said load. The radial load is applied to the casing thereby radially expanding the casing against the borehole wall so as to induce a compressive force between the casing and the surrounding formation.



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METHOD OF CREATING A WELLBORE IN AN UNDERGROUND FORMATION

The invention relates to a method of creating a wellbore in an underground formation, for example a wellbore for the production of oil or gas. Generally, when a wellbore for oil or gas production is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby each casing is installed after drilling a next interval, so that a next casing to be installed is to be lowered through a previously installed casing. In a conventional method of creating a wellbore the outer diameter of the next casing is limited by the inner diameter of the previously installed casing in order to allow lowering of the next casing through the previous casing. Thus, the casings are nested relative to each other, with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of the nested arrangement of the casings, a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid. Moreover, increased drilling rig time is involved due to required cement pumping and cement hardening.

It is an object of the invention to provide a method of creating a wellbore in an underground formation, which method eliminates the need for a relatively large borehole diameter in the upper part of the wellbore and thereby overcomes the disadvantages of the conventional method.

In accordance with the invention there is provided a method of creating a wellbore in an underground formation, comprising drilling a borehole in the underground formation, lowering a casing of a malleable material into the borehole, said casing being radially expansible against the borehole wall upon application of a radial load and having a smaller elastic radial deformation than the surrounding formation upon application of said load, and applying said radial load to the casing thereby radially expanding the casing against the borehole wall so as to induce a compressive force between the casing and the surrounding formation. After applying the radial load, the casing contracts slightly radially due elastic relaxation. However, the elastic radial deformation of the formation does not completely vanish following the relaxation due to the elastic radial deformation of the formation being larger than the elastic radial deformation of the casing. As a result thereof, a compressive force remains between the casing and the formation after relaxation, which compressive force ensures the casing being sealed to the formation. Thus, cement annuli are no longer required to seal the casing to the formation. Furthermore, it is achieved that casings of uniform diameter can be applied in the wellbore. By expanding the casing in the borehole the outer diameter of the next casing to be installed is not limited by the inner diameter of the previous casing before expansion thereof so that a nested arrangement of the casings is not required. It is to be understood that the casing being made of a malleable material implies that the casing material is capable of sustaining plastic deformation.

When a steel casing is applied, such casing normally has a smaller elastic radial deformation than the surrounding formation when the casing is expanded against the borehole wall by application of a radial load to the casing.

Preferably the material of the casing is capable of sustaining a plastic deformation of at least 25% uni-axial strain, so that the casing can be sufficiently expanded in the borehole without rupture of the casing material.

Advantageously the casing forms an intermediate casing located between a surface casing arranged in an upper part of the wellbore and a production casing arranged in a lower part of the wellbore.

When washouts occur in the borehole during drilling thereof, or when brittle formations are encountered, it can be desired to pump a sealing material in a fluidic state between the casing and the borehole wall prior to applying said radial load to the casing. For example, cement can be pumped in the annular space around the casing, which cement is allowed to harden after the casing has been expanded.

Plastic deformation of the casing can be promoted by heating the casing during radial expansion thereof.

A suitable casing joint to be employed for interconnecting two adjacent casings includes a section of a first casing provided with internal annular ribs having an inner diameter slightly larger than the outer diameter of a section of a second casing which extends into said section of the first casing. During expansion of the casing joint, the second casing is pressed against the ribs of the first casing whereby a metal to metal seal is achieved between said sections of the first and second casing. The ribs allow for some axial contraction of the second casing during radial expansion thereof.

An increase of speed of installing the casing in the borehole can be achieved by providing the casing continuously from a reel onto which the casing is stored before being lowered into the borehole, and unreeling from the reel during lowering into the borehole.

Furthermore, a considerable reduction of time and costs is achieved when the casing which is expanded in the borehole is also used as a drill string to drill the borehole. When for example the borehole is drilled using a tubing which is unreeled from a reel and to which a downhole motor driving a drill bit is connected (so-called coiled tubing drilling), the tubing can be expanded in the borehole to form a casing. The downhole motor and the drill bit remain in the borehole after expansion of the tubing.

The invention will now be described in more detail and by way of example, with reference to the accompanying drawings of which

Fig. 1 shows schematically a longitudinal section of a borehole in an underground formation and a casing lowered into the borehole;

Fig. 2 shows a hydraulic expansion tool in an unexpanded state positioned in a lower section of the casing of Fig. 1;

Fig. 3 shows the expansion tool in an expanded state;

Fig. 4 shows shows the expansion tool in the unexpanded state as the tool is moved to a next location;

Fig. 5 shows the the expansion tool in the expanded state at the next location; and

Fig. 6 shows an expander which is being moved through the casing.

Referring to Fig 1, there is shown a borehole 1 which has been drilled in an underground formation 3, and a steel casing 5 positioned concentrically in the borehole 1. The casing 5 is cylindrical and has a circular cross-section with an outer diameter smaller than the diameter of the borehole 1.

After the casing 5 has been lowered into the borehole 1, a hydraulic expansion tool 7 is lowered in an unexpanded state into a lower section of the casing 5, as shown in Fig. 2. The expansion tool 7 is connected to a surface pumping facility (not shown) by means of a hydraulic conduit 9. The tool 7 is expanded by operating the surface pumping facility thereby pumping hydraulic fluid through the conduit 9 and into the expander 7, as shown in Fig. 3. Pumping is stopped when the casing 5 at the location of the expansion tool 7 is expanded to an internal diameter slightly larger than the diameter of the borehole 1 as drilled. During expansion of the casing 5 against the borehole wall 4, the casing 5 undergoes elastic and plastic radial deformation, and the formation 3 surrounding the borehole 1 undergoes at least elastic radial deformation. It is to be understood that the elastic radial deformation of the casing 5 is significantly smaller than the plastic radial deformation thereof, and that the elastic radial

deformation of the surrounding formation 3 is significantly larger than the elastic radial deformation of the casing 5. After expansion of the casing 5 against the borehole wall 4, the hydraulic pressure in the tool 7 is removed allowing the tool 7 to contract to the unexpanded state, and allowing some elastic relaxation of the casing. The plastic deformation of the casing 5 remains, so that the elastic deformation of the underground formation 3 in the vicinity of the borehole wall 4 also remains. Thus, a compressive force remains between the casing 5 and the formation 3 due to the remaining plastic deformation of the casing 5.

As shown in Figs 4 and 5, after a lower section of the casing 5 has been radially expanded in this manner the expansion tool 7 is moved upward through the casing 5 in the unexpanded state and positioned at a next section of the casing 5, whereafter the tool 7 is expanded in order to expand the casing 5 similarly as described above. In this manner the casing 5 is expanded stepwise until the whole casing 5 has been radially expanded. Drilling of the wellbore 1 then proceeds using an underreamer drill bit (not shown), whereafter the next casing (not shown) is lowered through the previously expanded casing 5 to the newly drilled section of the wellbore 1.

The expander 22 shown in Fig. 7 can be used as an alternative to the hydraulic expansion tool 7. When the expander 22 is pushed downward through the casing 20 by an axial force F, the casing 20 is expanded to conform to the outer diameter of the expander 22, which outer diameter is selected such that the desired plastic radial deformation of the casing is achieved. By rotating the expander 22 during its movement through the casing 20 the axial friction between the expander 22 and the casing 20 is reduced. A further reduction of axial friction is achieved when the expander 22 is provided with rollers (not shown) which are capable of rolling along the inner surface of the casing 20 when the expander 22 is rotated, and by simultaneously rotating and axially moving the expander 22 through the casing 20. Radial deformation of the

casing 20 can be promoted by applying an internal pressure to the casing 20 when the expander 22 is moved through the casing 20.

In an alternative embodiment of the method according to the invention, a section of the interior of the casing in which a fluid is present is closed by means of two packers, whereafter the fluid is pressurised until the desired radial expansion of the casing is achieved. The alternative embodiment can also be used in conjunction with expansion by means of the hydraulic expansion tool or the expander described hereinbefore.

C L A I M S

1. A method of creating a wellbore in an underground formation, comprising drilling a borehole in the underground formation, lowering a casing of a malleable material into the borehole, said casing being radially expansible against the borehole wall upon application of a radial load and having a smaller elastic radial deformation than the surrounding formation upon application of said load, and applying said radial load to the casing thereby radially expanding the casing against the borehole wall so as to induce a compressive force between the casing and the surrounding formation.

2. The method of claim 1, wherein said material of the casing is capable of sustaining a plastic deformation of at least 25% uni-axial strain.

3. The method of claim 1 or 2, wherein said casing forms an intermediate casing located between a surface casing arranged in an upper part of the wellbore and a production casing arranged in a lower part of the wellbore.

4. The method of one of claims 1-3, wherein a sealing material in a fluidic state is pumped between the casing and the borehole wall prior to applying said radial load to the casing.

5. The method of one of claims 1-4, wherein at least part of said radial load is applied to the casing by moving an expander through the casing, which expander has a larger outer diameter than the inner diameter of the casing.

6. The method of claim 5, wherein said expander is provided with rollers which are capable of rolling along the inner surface of the casing when the expander is rotated, and the step of applying the radial load comprises simultaneously rotating the expander and moving the expander through the casing.

7. The method of claim 5 or 6, wherein an internal pressure is applied to the casing when the expander is moved through the casing so as to promote radial expansion of the casing.

8. The method of one of claims 1-4, wherein at least part of said radial load is applied to the casing by locating a hydraulic expansion tool in the casing and expanding said tool.

9. The method of one of claims 1-8, wherein the casing is heated during radial expansion thereof.

10. The method of one of claims 1-9, wherein said casing is stored on a reel before being lowered into the borehole and unreeled from the reel during lowering into the borehole.

11. The method of one of claims 1-10, wherein said casing is used as a drill string during drilling of the borehole.

12. The method substantially as described hereinbefore with reference to the drawings.

13. A wellbore created according to the method of one of claims 1-12.

FIG.3

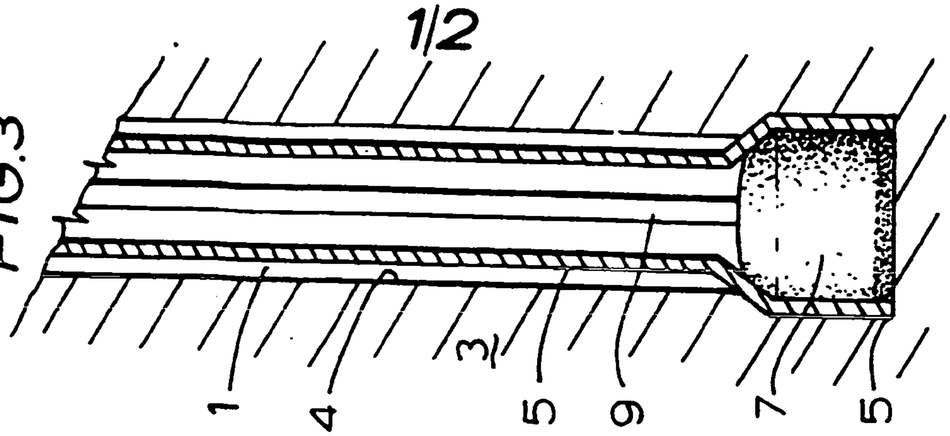

FIG.2

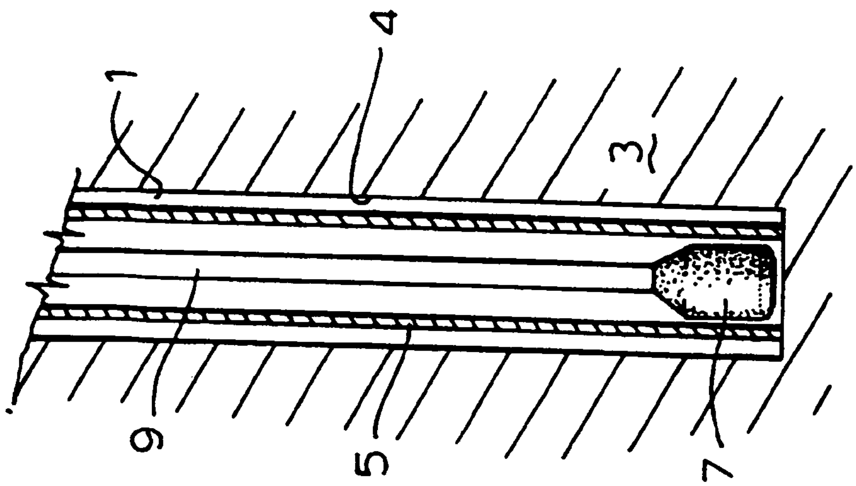

FIG.1

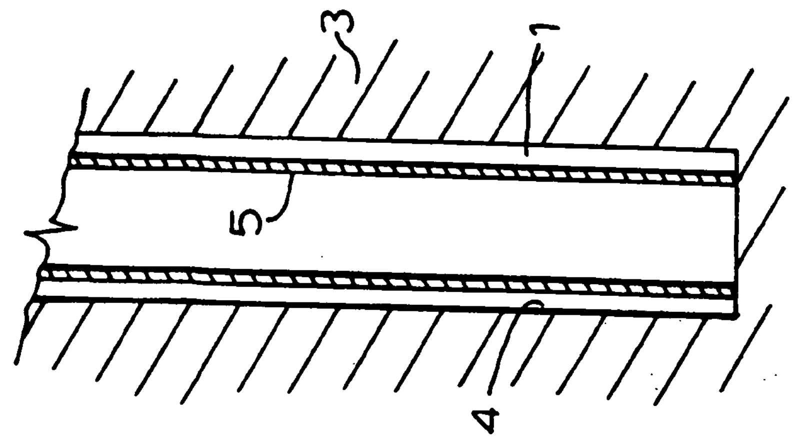

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FIG.6

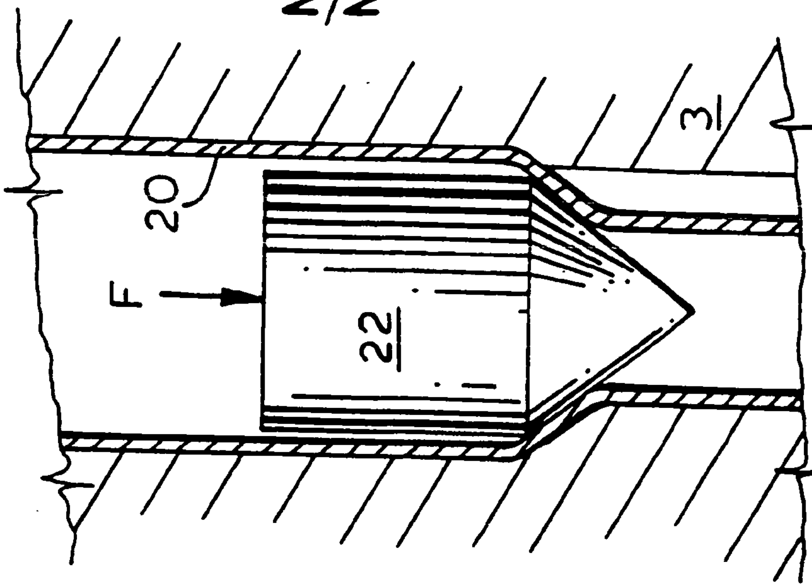


FIG.5

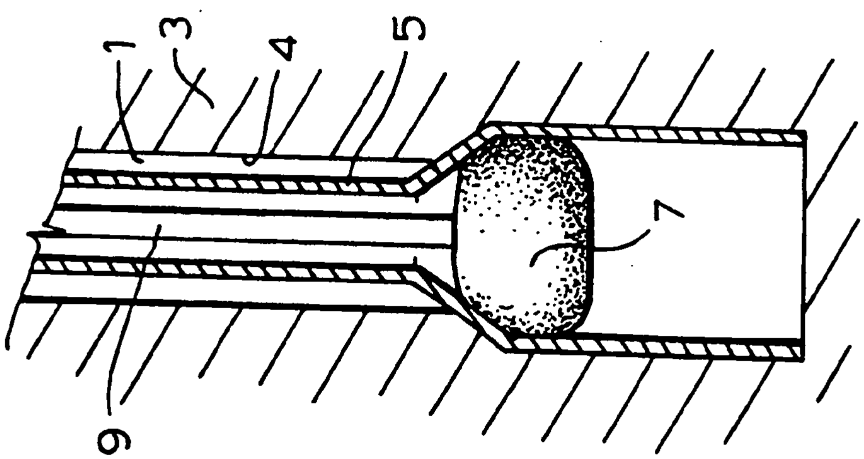
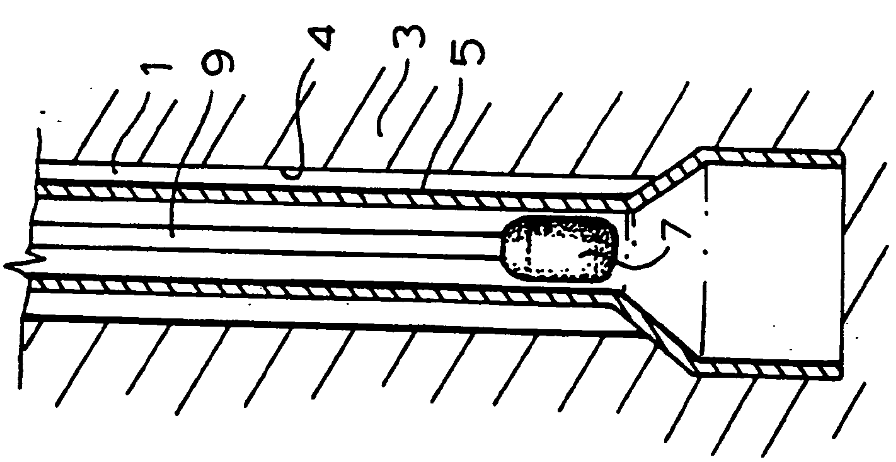


FIG.4



INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 93/01459

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 E21B43/10; E21B7/20; E21B33/14

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	E21B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US,A,3 477 506 (B.C.MALONE) 11 November 1969 see column 4, line 38 - line 54 see column 6, line 30 - line 44; figures 1,2	1,2,8, 12,13
Y		3-7,9-11

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Y	US,A,2 447 629 (V.J.BEISSINGER ET AL.) 24 August 1948 see column 5, line 48 - line 62; figures 1-5	3

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IV. CERTIFICATION

1

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

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